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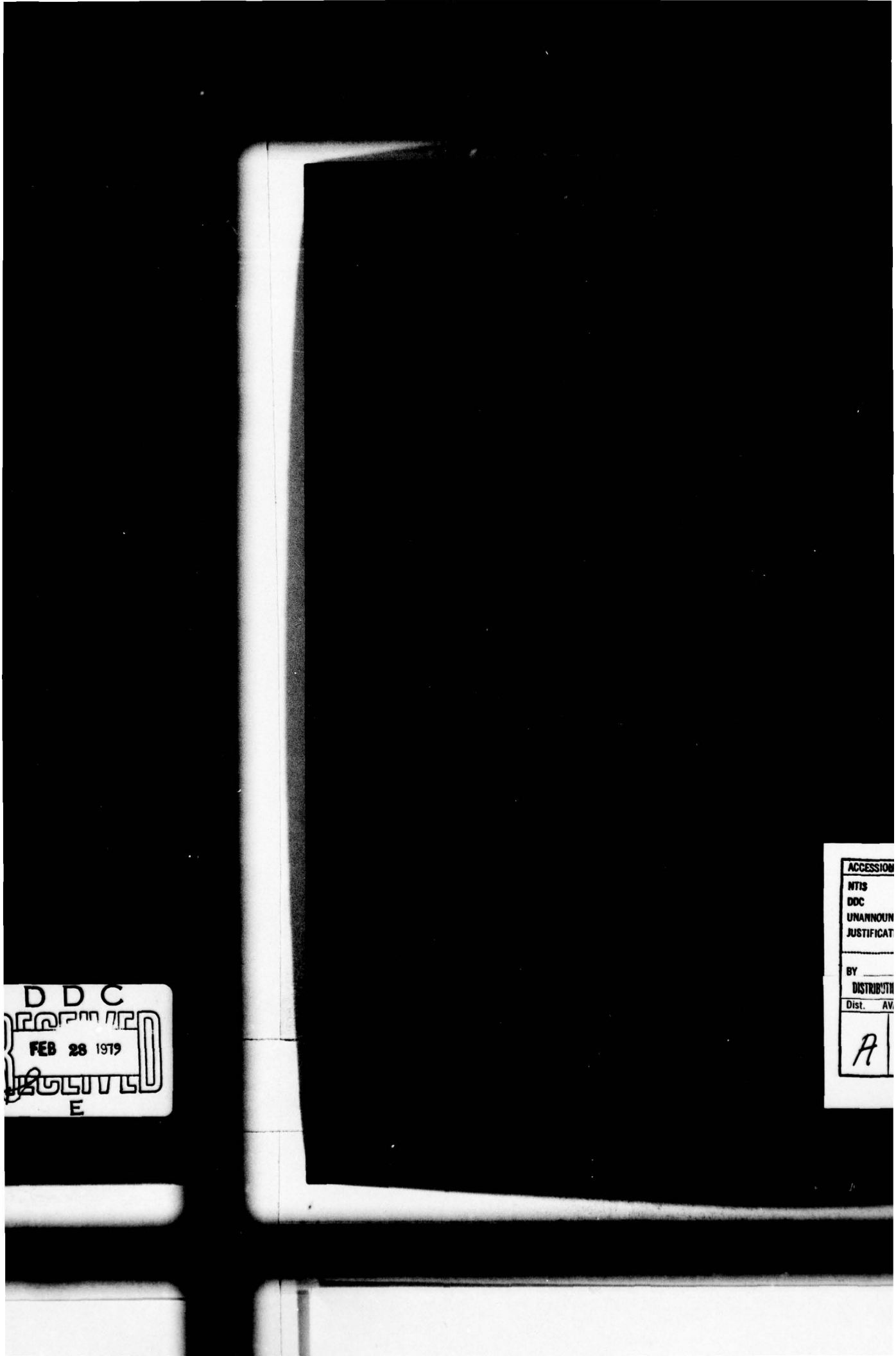

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

LINCOLN LABORATORY

ADVANCED ELECTRONIC TECHNOLOGY

QUARTERLY TECHNICAL SUMMARY REPORT TO THE AIR FORCE SYSTEMS COMMAND

1 AUGUST – 31 OCTOBER 1978

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LEXINGTON MASSACHUSETTS

INTRODUCTION

This Quarterly Technical Summary covers the period 1 August through 31 October 1978. It consolidates the reports of Division 2 (Data Systems) and Division 8 (Solid State) on the Advanced Electronic Technology Program.

CONTENTS

DATA SYSTEMS
DIVISION 2

INTRODUCTION

This section of the report reviews progress during the period 1 August through 31 October 1978 on Data Systems. Separate reports describing other work of Division 2 are issued for the following programs:

Seismic Discrimination	ARPA/NMRO
Distributed Sensor Networks	ARPA/IPTO
Education Technology	Bureau of Mines
Network Speech Systems Technology	OSD-DCA
Digital Voice Processing	AF/ESD
JTIDS Speech Processing	AF/ESD
Packet Speech Systems Technology	ARPA/IPTO
Radar Signal Processing Technology	ARMY/BMDATC
Nuclear Safety Designs	NRC

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DIGITAL INTEGRATED CIRCUITS
GROUP 23

I. INTRODUCTION

The 8-bit serial/parallel converter, fabricated with the poly-ox process, was operated at a 1-GHz serial data rate. 64K MNOS chips have been fabricated, but test results are not yet available. A model for charge storage in silicon nitride has been developed which, for the first time, can account for measured fatigue effects in MNOS devices.

II. HIGH-SPEED DIGITAL CIRCUITS

A. Serial/Parallel Converters

Chips from the first completed run of the new LL804 8-bit serial/parallel converter circuit and associated divider-multiplexer circuit were packaged and tested. Three packaged converter circuits operated correctly with an alternate 1-0 test pattern to 1.0 GHz. A test pattern generator, which produces several serial data patterns plus a parallel-transfer enable input, was constructed from the divider-multiplexer circuits and produced usable test patterns to 1.08 GHz. This was used to characterize one of the serial/parallel converters which operated correctly with a complementing 8-bit alternating 1-0 test pattern to 1.07 GHz.

B. Poly-Ox Process Development

The use of doped polysilicon as emitter and resistor dopant sources for the poly-ox process is being investigated. Smaller devices will be fabricated to improve the power-delay product.

III. MNOS MEMORY

A. 64K-Chip Fabrication

Further improvements were introduced into the 64K MNOS memory processing. A new process for masking the neon implant which is used to produce insulating damaged-silicon between digit lines was developed. Excellent digit line width control is obtained with negligible nitride removal during stripping of the mask. With 400 Å memory-nitride, which can be produced with good uniformity with the low-pressure CVD process, devices can be written with 22-V pulses.

Extensive first-to-second-level metal shorting which has been observed in the 64K chips is due to poor step coverage of the CVD oxide over plasma-etched first-level metal, which has very steep sidewalls. As an interim measure, a hybrid CVD oxide-plus-photoresist layer has produced substantially better results. Alternative between-metal insulators such as plasma-deposited oxide or nitride are being investigated. A process control technique which detects incomplete metal coverage by an electrolytic reaction at the site of an oxide void has been developed and will be used to optimize the oxide deposition process. The first decoded 3 × 3 arrays have been tested. The 64K bypass chip is only partially testable because of poor first-to-second-level metal contact.

B. MNOS Memory Decoding

A new device, the n-channel epi depletion transistor, has been fabricated and shown to work as expected. Its advantage over conventional n-channel MOSFETs, for our process, is that it

requires no additional processing steps. Detailed design of the second-generation memory has begun. It will use n- and p-channel transistors in a CMOS arrangement for the digit decoding and p-type resistors with p-channel transistors for the word decoding.

C. Testing

The automated test equipment is being checked out with undecoded 30 × 30 arrays. The digital storage scope interface is operational.

D. Model of Charge Storage in MNOS Memory Devices

Valence alternation pair (VAP) point-defects in a-Si_3N_4 provide a trap mechanism that is able to account for fatigue effects in MNOS memory devices as well as charge storage and decay phenomena. Nitrogen lone-pair electrons allow the VAP defect to occur. Silicon, possessing no lone-pairs, inhibits interconversion allowing all six VAP charge states to exist as localized states in the nitride gap. Localized states due to dangling bonds are eliminated from the gap because these bonds are tied up with hydrogen. The empty pair traps (N_4^+, N_2^-) form the ground state of the system, the singly-occupied pair traps (N_4^o, N_2^o) are the storage states, and the doubly-occupied pair traps (N_4^-, N_2^+) are the states responsible for fatigue effects in the nitride.

Incorporation of this trap structure into a model for an MNOS memory device requires several assumptions concerning the charge/discharge mechanism during the write-erase operation: (1) charge is injected and removed from the nitride by band-to-band tunneling through the oxide, (2) pronounced field detrapping of charge in the nitride takes place, and (3) the VAP defect density is high, of the order of 10^{20} cm^{-3}. The doubly-occupied (fatigued) state is due to the capture of a second charge-carrier by a singly-occupied (storage) state. Charge carriers cannot be detrapped by field-assisted emission from a fatigued state, so, as a result, they accumulate with the number of W/E operations. Charge carriers can escape from the fatigue state by back tunneling so that as $[N_4^-] \rightarrow [N_4^o]$ and $[N_2^+] \rightarrow [N_2^o]$ the short-term charge decay tends to increase with increasing $[N_4^-]$ and $[N_2^+]$. As $[N_4^-]$ and $[N_2^+]$ build up in the nitride in the vicinity of the oxide-nitride interface such that $[N_4^-] \rightarrow [N_{4T}]$ and $[N_2^+] \rightarrow [N_{2T}]$, the stored charge moves deeper into the nitride closing the memory voltage window and reducing the short-term charge decay. Recovery of fatigued devices (by definition $[N_4^-] \approx [N_{4T}]$ and $[N_2^+] \approx [N_{2T}]$) occurs by thermally-activated electron-transfer reactions between the fatigued VAP states, N_4^- and N_2^+.

Testing of this model through laser depopulation studies has begun. MNOS samples using (100) n-Si wafers and silicon-on-sapphire with and without transparent metal electrodes have been prepared and are being characterized optically. The energy levels of trapping states will be measured by use of a tunable laser.

IV. PROCESS DEVELOPMENT AND OPERATIONS

A. Laser Annealing

Work has been initiated to anneal integrated circuit silicon wafers by a focused argon laser beam. This work is aimed at providing new techniques of dielectric isolation and also improved methods for making faster devices. The latter follow from the very fast heating pulses which permit annealing ion implant damage without dopant redistribution: redistribution during conventional furnace anneals limits the maximum possible dopant gradients and therefore the minimum device sizes.

B. Process Simulation

SUPREM, an IC process modeling program obtained from Stanford University, has been installed on the IBM 370 computer. SUPREM is a batch program and features impurity modeling for (100) silicon as well as (111) silicon. There are several differences between SUPREM and our simulator, FABSIM, which should make comparison of results interesting.

COMPUTER SYSTEMS
GROUP 28

In addition to the continued general growth in computer use as previously reported, there has been a marked increase in interactive computing over the past fiscal year. This has resulted in a noticeable degradation in system response and lengthened turnaround times. Although the hours of operation have been extended to their practical limit and the systems tuned to optimum performance, it has not been possible to keep pace with the workload.

To provide the required matching capacity, a functional specification with performance capability demonstrations, has been prepared and distributed to vendors during the quarter.

Similarly, a specification and performance tests for the replacement of the obsolete Stromberg Datagraphix 4060 CRT plotter have been prepared and released. The heavily used SD4060 provides automatic plotting output for the Laboratory. It is increasingly subject to serious production delays caused by remedial maintenance problems on equipment no longer manufactured. Specifications for the replacement system also include features which will be aimed at providing document preparation capabilities.

A variety of other hardware and software tasks have also been completed during the quarter. In hardware, these include the installation of 600 megabytes of direct-access file storage and the installation of new line-junction modules for the internal Laboratory data calling system. In software and related areas, a modification to the VM/370 time-sharing system facilitates punched card output procedures for VS on a virtual machine and a revised version of the introductory computer training course have been presented and video taped for continued future use. An exploratory seminar series on software engineering is also in progress.

SOLID STATE
DIVISION 8

INTRODUCTION

This section of the report summarizes progress during the period 1 August through 31 October 1978. The Solid State Research Report for the same period describes the work of Division 8 in more detail. Funding is primarily provided by the Air Force, with additional support provided by the Army, ARPA, NSF, and DOE.

A. L. McWhorter
Head, Division 8

I. Melngailis
Associate Head

DIVISION 8 REPORTS
ON ADVANCED ELECTRONIC TECHNOLOGY

15 August through 15 November 1978

PUBLISHED REPORTS

Journal Articles

JA No.			
4772	GaInAsP/InP Double-Heterostructure Lasers for Fiber Optic Communications	J. J. Hsieh C. C. Shen	Fiber Integ. Opt. 1, 357 (1978)
4791A	Surface States on n-Type $SrTiO_3$	S. Ellialtioğlu* T. Wolfram* V. E. Henrich	Solid State Commun. 27, 321 (1978)
4804	Efficient cw Optically Pumped Ni:MgF_2	P. F. Moulton A. Mooradian T. B. Reed	Opt. Lett. 3, 164 (1978)
4809	High Na^+-Ion Conductivity in $Na_5YSi_4O_{12}$	H. Y-P. Hong J. A. Kafalas M. Bayard	Mater. Res. Bull. 13, 757 (1978)
4814	Optical and Electrical Properties of $CdGeAs_2$	G. W. Iseler H. Kildal N. Menyuk	J. Electron. Mater. 7, 737 (1978)
4823	Vapor Phase Growth of $Hg_{1-x}Cd_xTe$ Epitaxial Layers	P. Vohl C. M. Wolfe	J. Electron. Mater. 7, 659 (1978)
4835	Condon Internal Diffraction in the $O_u^+ \rightarrow O_g^+$ Fluorescence of Photoassociated Hg_2	D. J. Ehrlich R. M. Osgood, Jr.	Phys. Rev. Lett. 41, 547 (1978)
4854	Solar Cells: Plugging into the Sun	J. C. C. Fan	Technol. Rev. 80, 14 (1978)
4856	Gap-Coupled InSb/$LiNbO_3$ Acoustoelectric Convolver Operating at 77K	F. J. Leonberger R. W. Ralston S. A. Reible	Appl. Phys. Lett. 33, 484 (1978)

* Author not at Lincoln Laboratory.

UNPUBLISHED REPORTS

Journal Articles

JA No.			
4806	Rate Equations in Stimulated Light Scattering	P. L. Kelley	Accepted by Phys. Rev. A
4816	Pressure and Intensity Dependence of Multiphoton Energy Deposition and Reaction Yield in Vinyl Chloride	F. M. Lussier* J. I. Steinfeld* T. F. Deutsch	Accepted by Chem. Phys. Lett.
4843	Infrared Laser Photochemistry of Silane	T. F. Deutsch	Accepted by J. Chem. Phys.
4852	Transverse Modes in Gap-Coupled Surface Wave Devices	S. A. Reible	Accepted by Appl. Phys. Lett.
4859	An Acoustoelectric SAW/CCD Buffer Memory Device	D. L. Smythe R. W. Ralston B. E. Burke E. Stern	Accepted by Appl. Phys. Lett.
4862	Efficient Thallium Photodissociation Laser	D. J. Ehrlich J. Maya* R. M. Osgood, Jr.	Accepted by Appl. Phys. Lett.
4872	Frequencies, Line Strengths, and Assignments in the Doppler-Limited Spectrum of Formaldehyde from 2700-3000 cm^{-1}	L. R. Brown* R. H. Hunt* A. S. Pine	Accepted by J. Mol. Spectrosc.
4875	Vibrational Kinetics of SF_6 Dissolved in Simple Cryogenic Liquids	S. R. J. Brueck T. F. Deutsch R. M. Osgood, Jr.	Accepted by Chem. Phys. Lett.
4877	Energy Extraction from Metastable Excimers – Hg_2 as an Energy Storage Medium	D. J. Ehrlich R. M. Osgood, Jr.	Accepted by IEEE J. Quantum Electron.
4879	Enhancement of Nonlinear Optical Processes with a Double-Pass Tight-Focusing Geometry	S. R. J. Brueck H. Kildal	Accepted by Appl. Phys. Lett.
4880	Electrode Materials for the Photoelectrolysis of Water	J. G. Mavroides	Accepted by Mater. Res. Bull.
4883	Effect of H_2 on Residual Impurities in GaAs MBE Layers	A. R. Calawa	Accepted by Appl. Phys. Lett.

* Author not at Lincoln Laboratory.

JA No.

4884	Time and Magnetic Field Dependence of the Nickel Carbonylation Rate	R. S. Mehta* M. S. Dresselhaus* G. Dresselhaus* H. J. Zeiger	Accepted by Surf. Sci.
4886	Spectral Intensities in the ν_3-Bands of $^{12}CH_4$ and $^{13}CH_4$	M. Dang-Nhu* A. S. Pine A. G. Robiette*	Accepted by J. Mol. Spectrosc.
4887	Beryllium Ion Implantation in InP and $In_{1-x}Ga_xAs_yP_{1-y}$	J. P. Donnelly C. A. Armiento	Accepted by Appl. Phys. Lett.
4888	Collision Induced Predissociation in Photoassociated Hg_2	D. J. Ehrlich R. M. Osgood, Jr.	Accepted by Chem. Phys. Lett.
4890	P-n Junction Diodes in InP and $In_{1-x}Ga_xAs_yP_{1-y}$ Fabricated by Beryllium Ion Implantation	C. A. Armiento J. P. Donnelly S. H. Groves	Accepted by Appl. Phys. Lett.
4893	Efficient Frequency Tripling of CO_2 Laser Radiation in Tandem $CdGeAs_2$ Crystals	N. Menyuk G. W. Iseler	Accepted by Opt. Lett.

Meeting Speeches†

MS No.

4447C	Doppler-Limited Infrared Molecular Spectroscopy with a Tunable-Laser Difference-Frequency Converter	A. S. Pine	Seminar, Pennsylvania State University, University Park, 21 September 1978
4542B	Recent Advances in Laser Devices	A. Mooradian	Latin American Seminar on the Laser and Applications, La Plata, Argentina, 21-26 August 1978
4650A	Efficient cw Optically Pumped Ni:MgF_2 Laser	P. F. Moulton	Seminar, M.I.T., 28 September 1978
4654	Advances in GaAs Schottky Diode Submillimeter Heterodyne Receivers and Radiometers	P. E. Tannenwald	AGARD Symp. on Millimetre and Submillimetre Wave Propagation and Circuits, Munich, Germany, 4-8 September 1978
4689E	Fabrication and Applications of Submicron Structures	H. I. Smith D. C. Flanders M. W. Geis	Dry Etching Seminar, Danvers, Massachusetts, 10-11 October 1978
4701A	Solid State Electrochromic Displays Using Solid Electrolytes	M. Bayard	Gordon Research Conf., Tilton, New Hampshire, 31 July – 4 August 1978

* Author not at Lincoln Laboratory.

† Titles of Meeting Speeches are listed for information only. No copies are available for distribution.

MS No.			
4709A	Performance Requirements for Analog Signal Processors in Radar and Communication Systems	E. Stern	Society of Photo-Optical Instrumentation Engineers, 22nd Intl. Symp., San Diego, California, 28-31 August 1978
4802	Vibrational Kinetics in Cryogenic Liquids and Applications to Nonlinear Optics	S. R. J. Brueck T. F. Deutsch H. Kildal R. M. Osgood, Jr.	
4741	SAW/CCD Buffer Memory	D. L. Smythe R. W. Ralston E. Stern B. E. Burke	1978 Intl. Conf. on the Application of Charge Coupled Devices, San Diego, California, 25-27 October 1978
4744	Structural Aspects of Solid Electrolytes	H. Y-P. Hong	American Chemical Society Miami, Florida, 12-13 September 1978
4745	Development of NASICON, a Solid Electrolyte for High-Temperature Sodium Batteries	J. A. Kafalas	
4750	Oscillatory Magneto-Transmission of $In_{1-x}Ga_xAs_yP_{1-y}$ Alloys	K. Alavi* R. L. Aggarwal* S. H. Groves	First Intl. Conf. on Solids and Plasmas in High Magnetic Fields, M.I.T., 18-20 September 1978
4754	Growth of Undoped InP and $In_{1-x}Ga_xAs_yP_{1-y}$ by LPE	S. H. Groves M. C. Plonko	1978 Intl. Symp. on GaAs and Related Compounds, St. Louis, Missouri, 24-27 September 1978
4756	Properties of InP Doped with Fe, Cr, or Co	G. W. Iseler	
4779	Annealing of Se-Implanted GaAs and InP by Scanned Nd:YAG Laser Irradiation	J. C. C. Fan J. P. Donnelly C. O. Bozler R. L. Chapman	
4757	An Acoustoelectric Schottky-Diode Memory-Correlator Subsystem	D. H. Hurlburt R. W. Ralston R. P. Baker E. Stern	1978 Ultrasonics Symp., Cherry Hill, New Jersey, 25-27 September 1978
4758	Acoustoelectric Signal-Processing Devices with Charge Storage	J. H. Cafarella	
4759	Automated Pulsed Technique for Measuring the Phase and Amplitude Response of SAW Devices	J. H. Holtham R. C. Williamson	
4760	Gap-Coupled InSb/$LiNbO_3$ Convolver Operating at 77K	F. J. Leonberger R. W. Ralston S. A. Reible	

* Author not at Lincoln Laboratory.

MS No.			
4761	Interaction of Surface Waves and Bulk Waves in Gratings: Phase Shifts and a New Type of Resonance	J. Melngailis R. C. Williamson	1978 Ultrasonics Symp., Cherry Hill, New Jersey, 25-27 September 1978
4762	Transverse Modes in Acoustoelectric Convolvers	S. A. Reible K. L. Wang* V. S. Dolat	
4763	High-Performance Hybrid SAW Chirp-Fourier-Transform System	V. S. Dolat M. B. Schulz L. A. Veilleux G. R. McCully R. C. Williamson	
4766	Fast Synchronization in a Spread-Spectrum System Based on Acoustoelectric Convolvers	D. Brodtkorb J. E. Laynor	
4767	An Acoustoelectric SAW/CCD Device	D. L. Smythe R. W. Ralston B. E. Burke E. Stern	
4777	GaInAsP/InP Lasers and Detectors for Fiber Optics Communications at 1.0-1.6 μm	C. E. Hurwitz J. J. Hsieh J. N. Walpole S. H. Groves	EASCON '78, Washington, D.C., 24-27 September 1978
4777A	GaInAsP/InP Lasers and Detectors for Use at 1.0-1.6 μm	C. E. Hurwitz J. J. Hsieh J. N. Walpole S. H. Groves	Electrooptics/Laser '78 Conf., Boston, 19-21 September 1978
4780	mm-Wave Integrated Circuits for Strategic Sensors	R. W. Laton W. E. Courtney R. A. Murphy C. O. Bozler H. J. Stalzer G. B. Jones	Gov't Microcircuits Applications Conf., Monterey, California, 14-16 November 1978
4793	Zn-Diffused, Stripe-Geometry, Double-Heterostructure GaInAsP/InP Diode Lasers	J. J. Hsieh	6th IEEE Intl. Semiconductor Laser Conf., San Francisco, California, 29 October – 3 November 1978
4796	Condon Internal Diffraction in the Bound-Free Fluorescence of Photoassociated Heavy Metals	D. J. Ehrlich R. M. Osgood, Jr.	Laser Induced Processes in Molecules Conf., Heriot-Watt University, Edinburgh, Scotland, 20-22 September 1978
4796A	Collision Induced Predissociation in Photoasscciated Hg_2	D. J. Ehrlich R. M. Osgood, Jr.	31st Annual Gaseous Electronics Conf., Buffalo, New York, 17-20 October 1978

* Author not at Lincoln Laboratory.

MS No.			
4802A	Vibrational Kinetics in Cryogenic Liquids and Applications to Nonlinear Optics	S. R. J. Brueck	Seminar, Los Alamos Scientific Laboratory, New Mexico, 28 August 1978
4809	Evaluation of High-Speed 9-12 Micrometer Detectors Using Sub-Nanosecond Pulsed Pb Salt Lasers	K. W. Nill* J. F. Butler* D. L. Spears	22nd Intl. Technical Symp., San Diego, California, 30 August 1978
4814	Millimeter Wave Mosaic Receiver	R. A. Murphy W. T. Lindley	4th Joint Strategic Sciences Mtg., San Diego, California, 13-15 September 1978
4818	Design Requirements for an Electrooptic A/D Converter	F. J. Leonberger C. E. Woodward D. L. Spears	High-Speed A/D Conversion Workshop, Portland, Oregon, 16-17 October 1978

* Author not at Lincoln Laboratory.

SOLID STATE
DIVISION 8

I. SOLID STATE DEVICE RESEARCH

Multi-energy Be implants in n-type InP and $In_{1-x}Ga_xAs_yP_{1-y}$ have yielded layers with uniform as-implanted Be concentrations of approximately 3×10^{18} cm^{-3}. Sheet carrier concentrations, which were in the $(1\text{-}2) \times 10^{14}$ cm^{-2} range, were obtained on samples implanted at room temperature and annealed at 750° and 700°C for InP and InGaAsP, respectively.

P-n junction diodes have been formed by Be-implantation in n-type InP and $In_{1-x}Ga_xAs_yP_{1-y}$. Low leakage currents and abrupt voltage breakdowns were observed for both mesa and planar InP diodes. Scanning photoresponse measurements of the $In_{1-x}Ga_xAs_yP_{1-y}$ ($E_g \approx 1.0$ eV) mesa diodes showed uniform avalanche gains of 2 to 3 times.

Liquid-phase epitaxy has been used to reproducibly grow InP and InGaAsP alloys with $N_D - N_A$ at the low 10^{15} cm^{-3} level. The 77 K electron mobilities for the InP are in the 40,000- to 60,000-cm^2/V-sec range, with N_D/N_A between 2.5 and 6. For $In_{0.8}Ga_{0.2}As_{0.5}P_{0.5}$, the 77 K mobilities are 12,000 to 14,000 cm^2/V-sec with $N_D/N_A \leq 2$.

Analysis of measurements of the high-magnetic-field Hall coefficient versus temperature yields values for the concentrations of deep donors in InP and InGaAsP specimens of 5×10^{15} cm^{-3} and 3×10^{14} cm^{-3}, respectively. The transport data were fit using deep level donor activation energies of 0.29 and 0.12 eV for InP and InGaAsP, respectively. These energy values were inferred from the photoluminescence spectra.

In a study of photoluminescence of LPE-grown InP and InGaAsP, several spectral peaks were observed in a range 0.3 to 1.41 eV. An investigation is presently under way to test the hypothesis that one of the peaks in the photoluminescence spectra, with peak energies of 1.12 eV for InP and 0.9 eV for InGaAsP, is due to oxygen.

The oscillatory interband magneto-transmission has been measured on samples of LPE-grown $In_{0.77}Ga_{0.23}As_{0.52}P_{0.48}$ layers. The band parameters determined from the analysis of the data are $E_g = 1.07$ eV, $m_c^* = 0.061\ m_o$, and $E_p = 17.6$ eV, where these parameters are the direct energy gap at $T \approx 20$ K, the conduction band effective mass, and the $\vec{k} \cdot \vec{p}$ interaction energy, respectively.

II. QUANTUM ELECTRONICS

The $^4F_{3/2} \rightarrow {}^4I_{13/2}$ emission cross section of NdP_5O_{14} at 1.32 μm has been determined from both spontaneous and stimulated emission measurements. The relative performance of a flashlamp-excited NdP_5O_{14} laser at 1.32 and 1.05 μm has also been evaluated. At 1.32 μm, a multimode output energy of 2.7 mJ has been achieved with 1.6 J input.

A CW-pumped Ni:MgF_2 laser operating at 1.62 μm has been repetitively Q-switched at 100 Hz, yielding a peak power of 20 W with a power enhancement of $>10^3$. A distributed loss coefficient $\leq 10^{-3}$ cm^{-1} has been measured in the Ni:MgF_2 laser crystal.

Phasematched fourth-harmonic generation in $CdGeAs_2$ has been carried out. The measured effective fourth-order nonlinear coefficient is $\chi^{(4)}_{I,eff}/\epsilon_o = 8 \times 10^{-27}$ m^3/V^3. The contribution of cascade processes, connected with lower-order nonlinearities, to the effective third- and fourth-order nonlinear coefficients has been considered.

A tunable sideband submillimeter spectrometer has been constructed as a first step in developing submillimeter frequency standards. Several rotational transitions in D_2O and CO have been measured to high accuracy.

III. MATERIALS RESEARCH

In order to investigate the usefulness of laser heating for removing ion-implantation damage in GaAs, a study has been made of the effects of annealing with a CW Nd:YAG laser on the electrical properties of Se-doped samples. Good electrical activation of the Se donors has been achieved, but thermal stress due to laser heating can result in the formation of (111) slip planes that degrade the electrical characteristics.

To determine why Cr doping of InP has not yielded resistivities as high as those obtained for Fe-doped semi-insulating crystals used to provide substrates for epitaxial growth, the activation energy for thermally exciting electrons from the Cr acceptor level to the conduction band of InP has been determined from measurements of the Hall coefficient as a function of temperature. The activation energy was found to be 0.39 eV, indicating that Cr-doped samples have lower resistivities because the Cr level is considerably closer to the conduction band than is the Fe level (which has an activation energy of 0.65 eV), not because Cr is less soluble in InP than Fe.

IV. MICROELECTRONICS

A GaAs monolithic integrated circuit capable of receiving submillimeter-wavelength radiation coupled through a high-resistivity GaAs substrate has been fabricated. The circuit consists of a slot antenna coupled to a surface-oriented mixer diode by a section of coplanar transmission line and an integrated bypass capacitor. The conversion loss measured with this mixer module at 350 GHz was approximately 20 dB.

A system has been designed to make noise measurements related to charge transfer and charge detection on the 100- × 400-element imager for the GEODSS program. Using double-correlated sampling, noise-equivalent signals of 10 electrons at a 400-kHz data rate have been achieved from the floating diffusion output circuit of the imager.

A theoretical analysis has been made of the effect of sampling-finger width on the frequency response of the SAW/CCD buffer memory, and this analysis has been compared with the measured response of a prototype device. The measured response of the device falls off as predicted by theory.

Improved process control for parallel-plate plasma etching of low-pressure chemical vapor deposited films of silicon nitride and polycrystalline silicon has been achieved by constraining wafer temperatures to near room temperature. The lower etching rates obtained with this method are not significant when compared with the improved uniformity and reproducibility over methods that allow the wafer to be heated by the plasma.

V. SURFACE-WAVE TECHNOLOGY

A simplified model for the charge-storage process in acoustoelectric surface-acoustic-wave devices has been adopted; the many types of parametric interactions which occur in these devices can then be summarized within a unifying concept. Further, this conceptual view also identifies the kinds of signal-processing functions which are attainable. Devices which employ

two-signal parametric interactions are straightforwardly interrelated, and the concept also extends to higher-order interactions.

A series of very sharp stop bands has been observed in the transmission response of a 200-groove normal-incidence grating when the wavelength of an incident surface acoustic wave is within ±20 percent of the grating period. These stop bands are produced by resonant conversion in the grating of surface waves into bulk waves which reflect back and forth from bottom to top of the crystal.

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19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

digital computers
integrated circuitry
magnetic films
education technology
Lincoln Terminal System
computer systems
solid state devices
materials research
laser research
quantum electronics
microelectronics

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

This Quarterly Technical Summary covers the period 1 August through 31 October 1978. It consolidates the reports of Division 2 (Data Systems) and Division 8 (Solid State) on the Advanced Electronic Technology Program.

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